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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Provides tests for evaluating the performance characteristics of mines and demolitions. Covers safety evaluation, supplementary environmental and shock tests, and tests for weathering, fuze functioning, mine-fuze compatibility, effectiveness, bullet impact, blast sensitivity, sympathetic detonation, and parachute delivery. Discusses reliability, human factors and maintenance evaluations. Describes equipment and technique for determining burst height of bounding mines. Tabulates mine types and applications and physical characteristics of explosives. Not applicable to chemical mines.

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U. S. ARMY TEST AND EVALUATION COMMAND
DEVELOPMENT TEST II (EP) - SYSTEM TEST OPERATIONS PROCEDURES

AMSTE-RP-702-103
*Test Operations Procedure 4-2-505 22 April 1974

MINES AND DEMOLITIONS

SECTION I
GENERAL

1. Purpose and Scope. This TOP provides guidance for planning tests of mines and demolitions to assure their conformance with ROC's, DP's, and other requirements documents. Subtests are designed to satisfy the requirements for the particular test item and test type (Development Test I, II (EP), or III, or a customer test). These tests can be

*This TOP supersedes MTP 4-2-505, 26 June 1968.

selected from those listed in sections II and III. This TOP covers simulated environmental tests but does not include service phase tests or environmental tests at climatic test sites.

2. Background. Army mines are divided into two types: antitank (AT) and antipersonnel (APERS). In the past most land mines were designed to be buried just beneath the surface of the ground though some varieties could be placed on the ground. The current trend is toward design for placement on the surface.

All AT mines rely upon explosive content for their effectiveness; some, however, may contain an explosive in a configuration that will concentrate the destructive force in one direction. Such is the case with the shaped-charge mine (Monroe effect) which contains a conical cavity in the explosive, and the plate-charge mine (Misznay-Schardin effect) in which the explosive is positioned against the convex side of a metal plate (an example is the M-21). APERS mines also rely upon explosive energy. Some have no significant casing while others are encased in metal that will fragment. The bounding mine is a variety that launches an explosive warhead a few feet into the air where it can be more effective upon detonation.

A mine is a fuzed munition designed to function, or to be functioned remotely (command detonated), when a target comes within lethal range. Mines vary significantly in complexity and sophistication. The oldest type of mine, still in wide use, is the manually emplaced blast-type mine functioned when the target applies a sufficient force on the pressure plate. The newer mines are generally mass scatterable by artillery, missiles, or ground vehicle or aircraft dispensers. These mines automatically arm during the scattering process and function when one of the following events occurs: a target is sensed within the mine's lethal range, the mine is disturbed, or a predetermined time period expires. The last process is termed "self-destruct." A listing of various mine and fuze features is contained in appendix C along with similar information for demolitions.

Mines and demolitions are quite similar and can sometimes be used interchangeably. The following general differences apply: (a) Demolitions generally require more on-site assembly. (b) Demolitions are usually used against static targets and mines against moving targets. The static targets are obstacles, fortifications, supplies, and equipment. (c) The emplaced life of demolitions is usually shorter.

Demolition charges are generally of two types. The most common type is a charge assembled from standard initiating components and standard demolition explosives. The other type is the demolition kit, normally a special purpose item such as a mine clearing charge which is furnished with all components. The testing of demolition-initiating components is covered in TOP 4-2-045. Special nonexplosive demolition devices such as drilling equipment, burning torches, shielding devices, etc., which are utilized in removing enemy obstacles or creating obstructions, require special tests simulating conditions under which the devices are used, as specified in the requirements document.

3. Equipment and Facilities. Equipment and facilities are covered in the references of section II.

SECTION II
TEST PROCEDURES

4. Supporting Tests. Subtests (in preferred order of completion with respect to high-risk, short-duration) to be considered in formulating a complete test program, with TOP/MTP and other references, are as follows:

TEST SUBJECT TITLE	PUBLICATION NO.
a. Initial Inspection	4-2-502
b. Physical Characteristics	4-2-500
c. Safety Evaluation (refer to para 5)	4-2-502
Design Review	
Adequacy of Safety Features	
Confirmation of Functioning Loads (see also para 8)	
Special Sensitivity Tests	
Emplacement and Recovery Hazards	
Transportation and Rough Handling Tests	
Forty-Foot Drop Test	
Extreme-Temperature Functioning	
Temperature-Humidity	
Extreme-Temperature Storage	
d. Supplementary Environmental and Shock Tests (refer to para 6)	
High Humidity (refer to para 6.1)	4-2-820
Fungus Resistance (refer to para 6.2)	4-2-818
Salt Spray (Fog) (refer to para 6.3)	MIL-STD-810C

TEST SUBJECT TITLE	PUBLICATION NO.
Sand and Dust (refer to para 6.4)	4-2-819
Solar Radiation (refer to para 6.5)	4-2-826
Immersion (refer to para 6.6)	1-2-603 (when published)
Rain (refer to para 6.7)	2-2-815
e. Weathering Test (refer to para 7)	
f. Fuze Functioning Test (refer to para 8)	
g. Mine-Fuze Compatibility (refer to para 9)	
h. Effectiveness Tests (refer to para 10)	
i. Bullet Impact Test (refer to para 11)	
j. Blast Sensitivity and Sympathetic Detonation (refer to para 12)	
k. Parachute Delivery (refer to para 13)	4-2-509
l. Reliability (refer to para 14)	
m. Human Factors Evaluation (refer to para 15)	
n. Maintenance Evaluation (refer to para 16)	TECR 750-15

SECTION III
SUPPLEMENTARY INSTRUCTIONS

5. Safety Evaluation. Before undergoing other tests described in this TOP, the test item must have successfully completed the safety evaluation. The safety evaluation consists of a number of tests which are designed to assure safe handling and transportation of the item under various conditions. These include shock, vibration, and environmental tests that have safety implications. The scope of tests falling under the safety evaluation - e.g., high and low temperature tests - is usually adequate for evaluating the effect of conditions under study, and these tests normally do not have to be expanded during the remainder of the test program. Safety evaluation tests are covered by TOP/MTP 4-2-502.

6. Supplementary Environmental and Shock Tests. In addition to environmental tests conducted during the safety evaluation (TOP/MTP 4-2-502), the test director selects from the tests below those that he deems necessary considering requirements, potential use of the item, and prior

testing on the same or similar items. Some of the test items may be exposed to sequences of extreme environments that the materiel could encounter during its life. Appendix A of TOP/MTP 4-2-015 provides a general approach to sequential testing. These environments may include those of TOP/MTP 4-2-502. One sequence assumes that the item will be sent to the arctic, another that the item will be sent to the tropics, and another that it will be sent to the desert. After each exposure all items are examined and a representative sample test-fired. The remainder are sent through the next environments of the sequence.

The explosive loading of mines/demolitions is consistent with the nature of the environment and its potential effects. Items exposed to extreme temperatures should include some completely HE loaded items since extreme temperatures could significantly change the air gap between explosive components and thus adversely affect the ability of the fuze to properly initiate the main explosive charge. On the other hand, there is no reason to suspect that salt fog would adversely affect the main charge explosive and therefore no reason to expose fully HE loaded items to this environment.

The minimum sample size for any exposure is five. If the developer can provide adequate data to prove that the test item can satisfactorily withstand a particular environment, it is usually unnecessary to duplicate his tests.

6.1 High Humidity. The high humidity test is conducted in accordance with TOP/MTP 4-2-820.

6.2 Fungus Resistance. If fungus resistance can be ascertained by an examination of the materials composing the mine or demolition, and from certification by the developer that the materials used in the mine are fungus-inert or impregnated with fungus-resistant material, TOP/MTP 4-2-818 is followed. If a fungus test is necessary, MIL-STD-810C or MIL-STD-331 is followed.

6.3 Salt Spray (Fog). The salt spray (or salt fog) test is conducted in accordance with MIL-STD-810C.

6.4 Sand and Dust. This test is conducted when the possibility exists that sand or dust could interfere with moving parts. The dust test is conducted in accordance with TOP/MTP 4-2-819 and is applicable only to surface-emplaced items. There is no standardized sand test; items which are normally buried are therefore buried in sand.

6.5 Solar Radiation. This test, which is primarily for heat effects, is conducted as described in TOP/MTP 4-2-826. The test items are exposed to the intermediate solar radiation conditions of AR 70-38 for 5 days. The test item is then examined and functioned at the equivalent peak temperature (145° F or as otherwise determined).

In view of the high temperature tests of TOP/MTP 4-2-502, the solar radiation test may be unnecessary in many cases. In no case should a normally buried mine be exposed to this treatment.

6.6 Immersion. Depending upon the requirements, either of two immersion (waterproofness) tests may be conducted. MIL-STD-331 calls for immersion in water under 15 psi pressure for 60 minutes. A fluorescent solution permits examination for penetration under ultraviolet light. MIL-STD-810C calls for immersion under 36 inches of water for 2 hours. TOP 1-2-603 (when issued) provides additional guidance on immersion testing.

6.7 Rain. An immersion test would normally make a rain test unnecessary; if one is required, however, TOP/MTP 2-2-815 should be followed.

7. Weathering Test. The weathering test is conducted to determine the ability of tactically emplaced mines to withstand exposure to natural environments. It is applicable only to demolitions that would not be functioned immediately after assembly or development. The emplacement duration will be the required period specified by the item requirements document. If sufficient samples are available, the desired duration (which would be longer than the required) as well as shorter periods should be investigated.

The explosive content of the test items must permit periodic inspection of the armed items during the emplacement period and recovery of malfunctioning items. The use of fully HE loaded (both fuze and mine or charge) items is therefore usually precluded. As a general rule, the fuze and as many successive elements of the explosive train as possible should be HE loaded. When performance of the mine or main charge is to be investigated, the HE mine or charge should be weathered with inert fuzes along with HE fuzes on inert mines or charges. Upon completion of the emplacement period, the HE fuzes are disarmed, assembled to the HE mines or charges, armed, and then function tested.

As previously noted, the items are armed upon emplacement. Periodic inspections are made during the emplacement period to determine whether spontaneous functions have occurred.

8. Fuze Functioning Test.

8.1 Objective. To determine the functioning capability and characteristics of the test item.

8.2 Method. A fuze functioning test is conducted to determine whether the fuze satisfies the performance requirements and whether it is capable of withstanding the effects of shock and environmental conditions that require subsequent fuze operability. The performance characteristics, a through d below, are determined with unconditioned samples. These samples also serve as control samples for fuzes exposed to the shock and environmental conditions. The ability of a fuze to explosively initiate the next element of the explosive train is considered in paragraph 9.

The fuze functioning and compatibility tests are combined when feasible to conserve test hardware.

a. Arming delay time.

b. Fuze sensitivity. Whenever practical, a functioning influence of increasing strength should be applied to the armed fuze.

c. Antidisturbance sensitivity.

d. Self-destruct time.

The many types of mines and demolitions preclude the definition of test procedures that would be applicable to all fuzes. Fuze sensitivity and self-destruct performance are normally stressed, and the factors in a and c above must also be considered in any functioning test.

8.3 Data Required. Data are recorded as appropriate to the type of test.

8.4 Analytical Plan. The probability of functioning under the various conditions should be determined. Additionally, the limiting conditions under which the fuze will function should be tabulated.

9. Mine-Fuze Compatibility.

9.1 Objective. To assure that mines and their associated fuzes are compatible with respect to explosive propagation.

9.2 Method. Fully loaded HE mines are used in this test. Whenever possible, the fuzes are modified for static initiation so that the time of firing can safely be controlled. At least five samples are used for each possible fuze/mine combination. The order of functioning of the main explosive charge is determined in accordance with TOP/MTP 4-1-003.

9.3 Data. Each detonation is recorded as complete or incomplete in accordance with TOP/MTP 4-1-003.

9.4 Analytical Plan. Any incomplete detonation is considered a deficiency and must either be explained by the test agency or resolved by the developer.

10. Effectiveness Tests.

10.1 Antitank Mines.

10.1.1 Objective. This test is designed to assure that the effectiveness requirements stated in the ROC/DP or other requirements document can be met.

10.1.2 Method. AT mines are designed to defeat tanks by two means. The blast type mine immobilizes a tank by breaking the track. Mines employing explosive wave shaping are primarily designed to penetrate the armor with resulting disastrous consequences to the vehicle and crew; they also have a track breaking capability when detonated under the track. The blast type mines are tested against tank track only. The armor penetrating mines are primarily tested against armor only; when samples are available, however, tests against tank track should also be conducted with the armor penetrating mines. Track breaking and armor penetration tests are described separately below.

a. Tank Track. The following factors are considered in establishing the test parameters:

Single pin track is, as a rule, much less vulnerable to mines than double pin track. The United States uses double pin track on medium and heavy tanks while most other countries use single pin track. The required single pin track is of necessity generally manufactured from captured samples of foreign track. The resulting supply is expensive and sometimes almost nonexistent.

Mines are least effective when detonated under the first or last roadwheel. They are most effective when detonated between roadwheels. The effectiveness at the between-roadwheels location is not significantly greater, though, than under an intermediate roadwheel. Most modern mines are fuzed to detonate beyond the first roadwheel of an armored vehicle. Fuze functioning location data are used in establishing location.

A mine is most effective when centered under the track; effectiveness decreases as the mine location moves toward the track edge. The direction of movement (inboard or outboard of the centerline) is immaterial. The distance from the centerline is the primary variable factor considered in test design. The first mine tested is usually located midway between the track centerline and outboard edge. Subsequent locations are based on the results obtained.

Soil type and condition have a pronounced influence on effectiveness. Clay, for example, significantly increases mine effectiveness and should therefore be avoided in testing the effectiveness of United States blast type mines. Using steel plates as targets, limited tests reported in reference 18 (app. A) showed that 67% more weight of explosive is required in dry sand to produce damage equivalent to that caused in wet clay. Dry sand required 46% more explosive than wet sand. In general, hardness of soil increases mine effectiveness as does saturation of soil with water. Unless otherwise specified, mine effectiveness tests should be conducted in an average dry soil, such as fairly dry loam or sandy loam.

Emplacement depth has an effect and should be that specified for the particular mine.

The tank track can be mounted on a target tank or on a test rig that simulates tank suspension. Use of a test rig can eliminate the time consuming and expensive repair of the target vehicle suspension system.

Mine shape and orientation can generally be ignored unless an extreme length-to-width or -depth ratio exists.

Completely HE loaded items are used, with the fuze modified for static initiation so that the time of detonation can be safely controlled. The mine is emplaced at the specified depth and located so that it will be at the desired location under the vehicle or test rig. When a target vehicle is used, the mine should be emplaced in the vehicle path and the vehicle then pulled over the mine. Damage to the track and vehicle suspension system is recorded following detonation.

b. Armor Plate. Fully loaded HE mines modified for static initiation are again used in this test. The mines are emplaced under armor plate at the normal buried depth with the underside of the plate parallel to and 18 inches above the soil surface. Three-inch-thick rolled homogeneous armor plate is used unless otherwise specified by the requirements document.

10.1.3 Data Required. Armor plate damage is recorded as described in TOP/MTP 2-2-710. Damage to track, belly armor, and internal components is recorded. When incomplete breakage occurs, the percent of the total width defeated is recorded. A description of the soil is also recorded.

10.1.4 Analytical Plan. Performance against tank track is analyzed in terms of the probability of damage sufficient to immobilize the tank (often called a mobility kill) occurring as a result of mines randomly encountered across the full width of the track.

Performance against armor plate is analyzed in terms of the probability of an open break in the armor occurring, and the likelihood that a bulge will cause serious damage. Possible effect on personnel is assessed.

10.2 Antipersonnel Mines.

10.2.1 Objective. To evaluate the effectiveness of APERS mines in accordance with ROC/DP requirements and other requirements as directed or deemed necessary.

10.2.2 Method. Fully loaded HE APERS mines modified for static detonation are used. The method applicable to each of the three types of effects considered is specified below.

a. Fragmentation Mines. There are three types of fragmentation mines: (1) a small explosive encased in metal which is placed on the ground and detonated usually by a tripwire or by pressure, (2) a linear explosive with a convex face that is lined with preformed fragments which, after command detonation, are thrown out in an acute angle essentially parallel to the ground (the Claymore is such a mine), and (3) a bounding mine which is buried in the ground and which, upon initiation, causes a propellant to throw the warhead portion of the mine into the air. Functioning usually occurs at 4 to 6 feet. (The M16 is such a mine. At one time they were called the "bounding Betty.") The bounding mine (app. B) is sometimes detonated against vehicular armor in the manner described in TOP 2-2-617 and reference 17 (app. A).

Velocity, weight, and distribution of fragments are determined in accordance with TOP/MTP 4-2-813. Lethal area computations are made when required. A sample of three mines is required for each realistic positioning of the mine; i.e., on the ground for most mines but several feet in the air for bounding mines.

b. Blast Mines. The effectiveness of these mines is determined by the Wound Ballistics Branch of the U. S. Army Ballistics Research Laboratories, Aberdeen Proving Ground, Md., and the data provided to the test agency.

c. Shaped Charge Mines. (Same as para b. The M25 is such a mine.)

10.2.3 Data Required. The exact conditions under which the mine was detonated and detailed descriptions of the targets before and after mine detonation are recorded. In the case of fragmenting mines, data are presented in the manner of TOP/MTP 4-2-813 and lethal areas computed.

10.3 Demolition Charges.

10.3.1 Objective. To evaluate the effectiveness of demolition charges in accordance with ROC/DP or other requirements. The measure of effectiveness depends on the purpose for which the demolition will be used.

10.3.2 Method. Effectiveness of a demolition charge is usually based on comparison with TNT which is arbitrarily rated as 1.00 (see app. C, table 2 and FM 5-25, ch. 1). Effectiveness can also be measured by comparison with other demolitions or by measuring detonation velocity when the latter is an important factor relative to the effects desired from the demolition. Table 1-1 of FM 5-25 (summarized in app. C) lists characteristics of 14 different types of explosives used by the Army including the velocity of the detonation to be expected from each. The six general uses to which these demolitions are applied (FM 5-25) are: timber cutting, steel cutting, pressure (reinforced concrete, T-beam bridges, cantilever bridges), breaching (concrete slab bridges, piers, and permanent field fortification), cratering and ditching, and land clearing and quarrying. Methods for setting up the tests for these applications are also provided in FM 5-25. The specific method to be used depends upon the particular item being tested and the criteria listed in the requirements documents or the test directive. Tests of demolition initiating equipment are covered in TOP 4-2-045.

The item is tested in the manner in which it is intended to be employed. Thus, if the item is intended to breach barbed wire, it is tested in a realistic manner against typical military barbed wire configurations. If it is intended to cut a certain size timber, it is so tested, etc. A typical example of a test of a demolition designed as a cratering charge follows. The objectives of the test are:

a. To determine whether the kit can safely and reliably produce a crater at least 15 feet in diameter (25 feet desired), 7 feet deep, and with side slopes of at least 30 degrees.

b. To determine whether an effective obstacle to tracked and wheeled vehicles can be produced by three kits in a 20-foot-wide road and five kits in a 30-foot road. An effective obstacle would require at least three attempts by an M48 or M60 tank to surmount the obstacle.

Forty-three kits are required for this test. They are expended in groups of one, three, and five kits against reinforced concrete roads and soil.

For the craters produced by single kits, the diameter is measured along two perpendicular axes and the depth is measured at both the 1/4 and 1/2 diameter points. For the obstacles produced by three and five kits, enough measurements are taken to be able to obtain comparative results. The failure of the tank to cross or the number of times required to cross (up to a maximum of six) is recorded. During a representative sample of the employment, the total time to make the kit ready for firing is recorded (both with and without arctic clothing).

10.3.3 Data Required. The specific characteristics of the item (road, soil, fortification, equipment, beam, minefield, etc.) against which the demolition is employed are recorded. The exact positioning of the demolition and the type of fuze are also recorded. After the demolition is detonated, detailed information on results is recorded and an assessment is made of the effectiveness of the demolition. (In the cratering-charge example, for instance, the attempts of the tank to climb out of the crater and the results are noted.)

10.3.4 Analytical Plan. The results are conveniently tabulated, and where information exists, comparisons are made with other demolitions.

11. Bullet Impact Test.

11.1 Objective. To determine the effects of bullet impact on the safety of the test item.

11.2 Standards. Standards for acceptability are contained in the ROC/DP and other guidance documents.

11.3 Method.

a. The following test details are determined:

(1) Number of test items.

(2) Packaging (packaged or unpackaged).

(3) Number of rounds to be fired.

(4) Caliber and type of ammunition.

b. The firing distance, if not specified, is generally a compromise between the distance that provides a high degree of assurance that the target can be hit and the distance at which the equipment at the firing position is reasonably safe from a test item detonation.

c. Selected small arms ammunition is fired into the test items, and observations are made for complete or partial detonation of the test items and for low or high order detonations.

11.4 Data Required. The following are recorded:

a. Number, type and caliber of rounds fired.

b. Location and results of each impact, including high or low order detonation.

c. An evaluation, if detonation does not occur, of safety of disposal.

11.5 Analytical Plan. The results obtained are compared to the requirements document criteria. If no criterion exists, the results are presented for informational purposes.

12. Blast Sensitivity and Sympathetic Detonation Test.

12.1 Objective. To determine the susceptibility of the test item to blast or sympathetic detonation.

12.2 Standards. Standards for acceptability are contained in the ROC/DP or other guidance documents. For manually emplaced mines the detonation of one mine should not set off an adjacent mine.

12.3 Method.

a. Two types of blast sensitivity tests should be considered. For reasons of safety, the mines exposed to detonation will normally have an inert main charge.

(1) Blast Sensitivity - To determine the effects of explosions on an armed test item. The charge that is purposely detonated may be different from that of the test item, and both the charge weight and the distance from the charge to the test item may be varied. This test can be used to simulate a condition in which enemy artillery is used to try to destroy a minefield.

(2) Sympathetic Detonation - To determine whether the specified separation distance between mines will preclude the functioning, or damaging to the extent of inoperability, of armed test items from the effects of the detonation of another item.

b. For the blast sensitivity test, the charges to be detonated are placed at the prescribed distance from the mine (or demolition). When appropriate, additional charges are detonated at various distances in an attempt to bracket the critical distance for detonation.

c. For the sympathetic detonation test, the test items are tactically emplaced, completely live with fuzes armed, at the prescribed minimum separation distance from a mine that has been fixed for static detonation. At most, three mines, separated 120° apart, can be used to surround the mine to be detonated.

12.4 Data Required. The following are recorded:

a. Parameters and configuration of the test setups.

b. Results after each static firing.

12.5 Analytical Plan. A sketch is prepared to illustrate the parameters and test configuration. Test results are examined to determine conformance with requirements.

13. Parachute Delivery Test. If a specific requirement for aerial delivery is contained in the guidance document, a parachute delivery test is conducted. Engineering judgment is used as the basis for determining whether the drop should be actual or simulated. When no requirement for aerial delivery is stated, engineering judgment is used to determine whether a parachute delivery test is necessary.

The parachute delivery test is conducted in accordance with TOP/MTP 4-2-509.

14. Reliability. When a reliability requirement is stated, TOP/MTP 3-1-002 is used to determine sample size and to determine whether the desired functioning reliability is achieved with the desired confidence. A precise definition of satisfactory performance is a prerequisite to a reliability analysis. Two reliability analyses are made: (a) overall reliability which includes a summation of all the satisfactory and unsatisfactory samples of each subtest and (b) selected reliability which includes all sample groups except those in which the test items suffered damage or deterioration during environmental or rough handling tests and groups in which statistically significant failures occurred in a particular subtest.

15. Human Factors Evaluation. The human factors evaluation, like the reliability analysis, is categorized as a separate subtest, but it is conducted throughout the test program. It involves determining the ease with which all of the functions such as unpacking, fuzing, arming, etc., can be performed both under ordinary conditions and while wearing arctic clothing. Where problem areas are encountered, recommendations should be made regarding improvements.

16. Maintenance Evaluation. A maintenance evaluation is also categorized as a separate subtest but is conducted throughout the entire test. Mines and demolitions require very little, if any, maintenance. The limited maintenance evaluation covers only the portions of TECR 750-15 that are applicable. This may include an evaluation of tools and equipment, equipment publications, and design for maintainability.

APPENDIX A
REFERENCES

1. AR 70-10, "Test and Evaluation During Development and Acquisition of Materiel."

2. AR 70-38, "Research Development, Test, and Evaluation of Materiel for Extreme Climatic Conditions."

3. AR 71-6, "Type Classification/Reclassification of Army Materiel."

4. AR 702-3, "Army Materiel Reliability, Availability, and Maintainability (RAM)."

5. AR 750-1, "Army Materiel Maintenance Concepts and Policies."

6. TM 9-1345-200, "Land Mines."

7. FM 5-25, "Explosives and Demolitions," February 1971.

8. AMCR 750-15, "Integrated Logistics Support."

9. AMCR 702-3, "Reliability Handbook."

10. AMCP 706-134, "Maintainability Guide for Design."

11. AMCP 706-177, "Explosives Series - Properties of Explosives of Military Interest," January 1971.

12. MIL-STD-331, "Fuze and Fuze Components, Environmental and Performance Tests For."

13. MIL-STD-810C, "Environmental Test Methods."

14. MIL-STD-1472A, "Human Engineering Design Criteria for Military Systems, Equipment and Facilities."

15. TECR 750-15, "Maintenance Evaluation During Testing."

16. Steinbach, R., "Special Study of Mine Burst Height Determination," Aberdeen Proving Ground, Md., Report APG-MT-3995, December 1971.

17. VanCaneghem, Rene J., "Final Report on Special Study of Data Analysis to Develop Standardized Mine Test for Lightly Armed Vehicles," TECOM Project 9-CO-001-000-041, Aberdeen Proving Ground, Md., Report APG-MT-4002, February 1972.

18. Eddy, J. R., "Final Report on Special Study of Effect of Soil Conditions on Mine Blast," TECOM Project 9-CO-001-000-047, Aberdeen Proving Ground, Md., Report APG-MT-4136, January 1973.

APPENDIX B
BURST HEIGHT DETERMINATION FOR BOUNDING MINES

1. Introduction. This appendix describes a method of recording the burst height of antipersonnel bounding mines on Polaroid film. The projectile burst is recorded, along with height reference markings, during a time exposure made with a neutral density (ND) filter. The filter limits the recorded image of the detonation flash to the most brilliant portion originating from the projectile - thus permitting identification of the projectile location at the time of detonation. The filter also permits sufficient light to pass during the time exposure (about 3 seconds) so that background details, including height reference markings, are recorded.

The content of this appendix is based on a study to develop a method of determining burst heights which would be as accurate as, and less expensive than, high-speed photography. The study is reported in reference 16 (app. A).

2. Equipment Required. A still camera with time-exposure and Polaroid film is required. The lens focal length must, however, be greatly increased by the additional of a telescope or similar optic device. A lens focal length of at least 100 inches is considered necessary so that the camera can be positioned at a safe distance from the mine and still produce an optimum field of view. A separation distance of at least 250 feet between mine and camera and a field of view of 10 feet at this distance is needed. The components used in assembling the unit shown in figure 1 were selected, to an extent, on the basis of availability are are not necessarily optimum. Comments are therefore provided on the suitability of each component used.

a. PH-47J Camera. This camera is used because it incorporates the the following features:

(1) A ground-glass viewing screen.

(2) A time-exposure capability. The camera unit is positioned immediately adjacent to a personnel shelter (bombproof) and a cable release used to control the camera shutter from within the shelter.

b. Polaroid Land No. 500 Filmholder. This permits the use of sheet film so that the holder can be removed whenever use of the ground-glass viewing screen is desired.

c. M49 Telescope. This 20-power telescope, with the camera 5-inch lens, is used so that the desired focal length of 100 inches is attained. A variable power telescope is desirable to allow flexibility in changing the field of view.

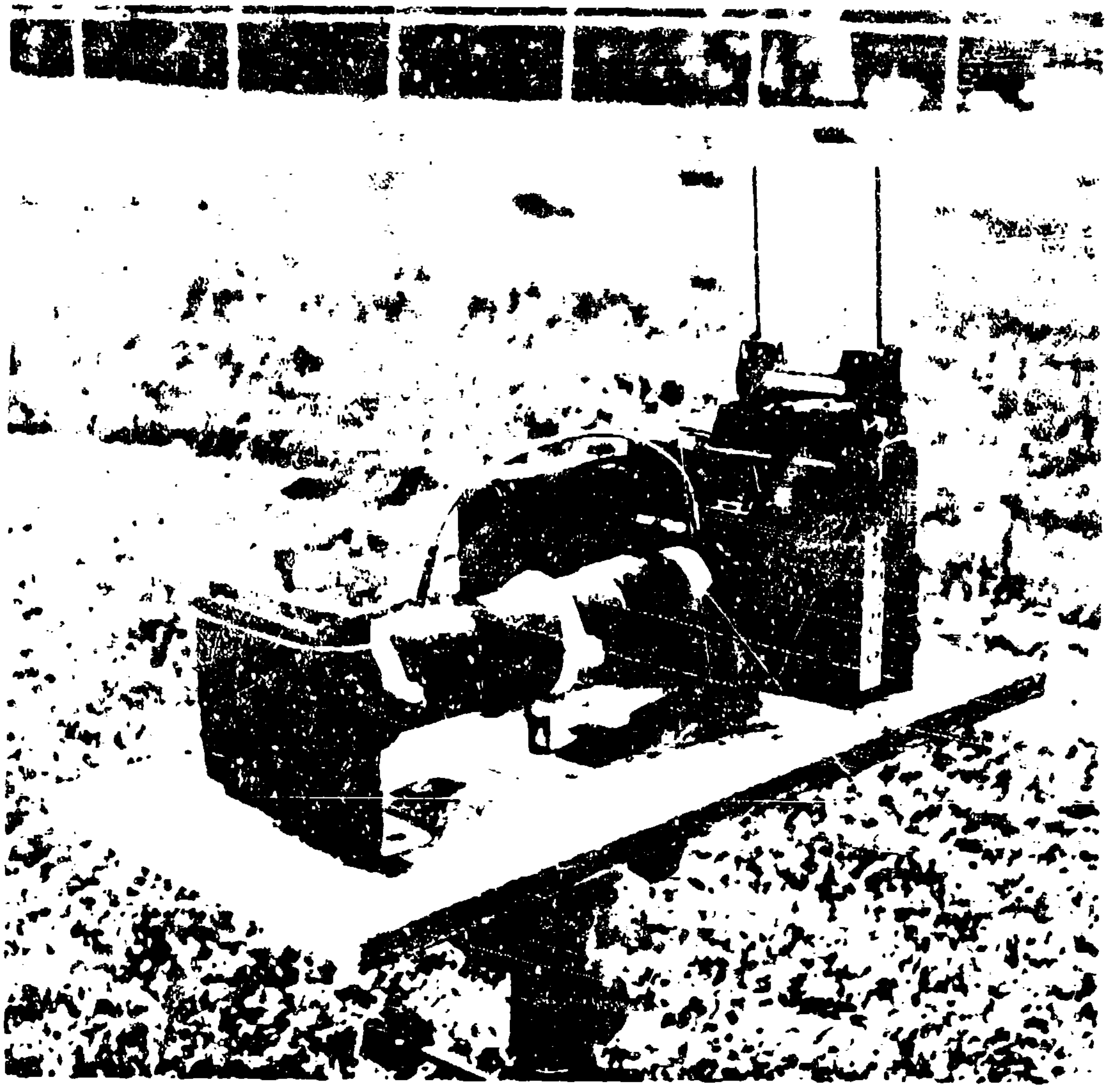

Figure 1. Assembled Equipment.

d. Kodak No. 96 Neutral Density Filters. Three gelatin filters with density values of 0.50, 1.00, and 2.00 are sufficient when either black and white or color film is used. The percent of light transmitted by the filters is 32, 10, and 1, respectively. Glass filters are recommended since gelatin filters are easily damaged by moisture or handling.

e. Camera Tripod. A rigid and readily adjustable tripod is required.

f. Improvised Mount. A plywood base, bolted to the tripod head, is functionally adequate. The camera is bolted to the plywood and the telescope held by two pipe clamps. An improvised filter mount is used to hold the filters on the telescope. The mounts must permit focusing adjustment of the camera lens.

g. Background Screen. A black background is required to provide the contrast necessary for easy location of the projectile burst. The background evident in figure 2 is an 8-foot-square plywood panel painted flat black. The panel is located about 30 feet beyond the mine. The distances between the horizontal white strips are scaled to represent 1-foot increments at the mine position.

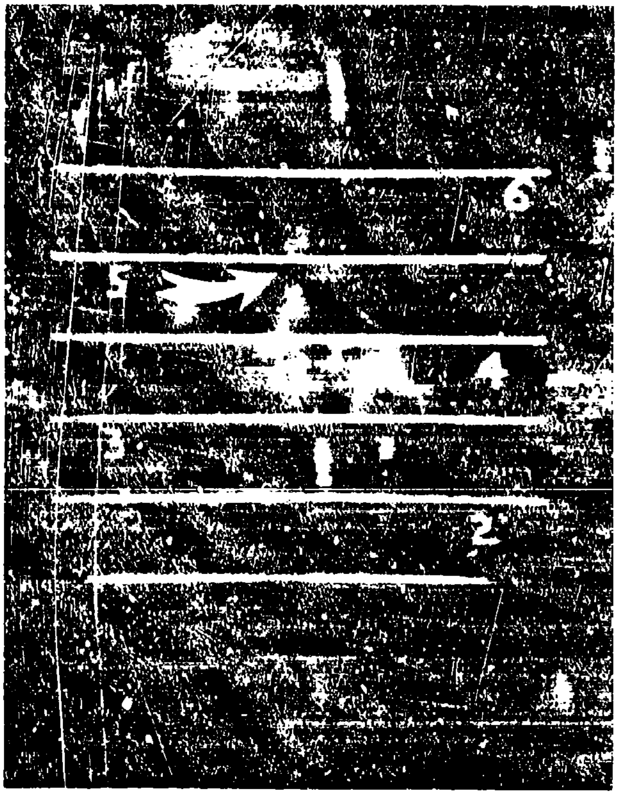

Figure 2. Projectile Burst.

h. Film. Polapan type 52 (black and white) and Polacolor type 58 sheet film are used. Color film is recommended, however, because it permits easier identification of the burst.

3. Procedure. The following steps are taken:

a. Assemble the tripod, mount, and camera.

b. Open both the lens aperture and shutter. The aperture is to remain open at all times.

c. Using the ground-glass viewing screen, align the camera with the mine firing position.

d. Adjust the separation distance between the telescope eyepiece and the camera lens until a sharp image is obtained on the ground-glass viewing screen. Secure the items in this position and seal the juncture from light using opaque tape.

e. Close the camera shutter and install the filter(s) on the telescope. A 2.00 density value filter is installed if black and white film is used. Combined 0.50 and 1.00 value filters are installed if color film is used. A test photograph is suggested at this point to check system operability and camera alignment. This is accomplished by making a 3-second exposure.

f. Emplace the mine and prepare it for remote fuze actuation.

g. Open the camera shutter. The mine fuze must be ready for actuation immediately after shutter opening.

h. Actuate the mine fuze.

i. Close the camera shutter as soon as the mine detonates (a total exposure time of 3 to 5 seconds is normal).

j. Develop the film.

k. Visually examine the resulting photograph to determine the projectile burst location. The burst will generally appear on the film as recorded streaks of light spreading outward from a central area having the approximate dimensions of the projectile. The burst of an M16 mine projectile is indicated by the arrow in figure 2.

l. Repeat steps f through k for subsequent firings.

APPENDIX C
TYPES OF MINES, DEMOLITIONS, AND EXPLOSIVES

Table 1 illustrates the variety of effects and sensing devices involved with mines and demolitions. Detailed descriptions of standard items are contained in TM 9-1345-200 and FM 5-25.

Table 1 - Types of Mines and Sensing Methods

	Antitank Mines	Antipersonnel Mines	Firing Devices for Demolitions
Types of Effects	Blast Chemical Shaped Charge Plate charge Implosive fragmentation	Blast Chemical Shaped charge Bounding fragmentation Mixed fragmentation	Blast Shaped charge
Types of Sensing	Acoustic Attenuation or cutting, e.g., a beam of light Infrared Magnetic Pressure Vibration Combinations Disturbance Self-destruct	Command, i.e., fired by friendly forces Pressure Pull (tripwire) Disturbance Self-destruct	Command Acoustic Chemical delay Clock delay Concussion Pressure Pressure/release Pull Pull/release Release

Table 2 contains a listing of unclassified explosives used for demolitions extracted from TM 9-1345-200. Additional details on the properties of these explosives are contained in AMCP 706-177.

Table 2 - Explosives Used for Demolition Purposes

Name	Composition	Principal Uses	Velocity of Detonation, meters/sec.	Relative Effectiveness as a Breaching Charge[1]	Intensity of Poisonous Fumes	Water Resistance
Ammonium Nitrate	100% NH_4NO_3	Demolition charge, comp explosives	2,700	---	Dangerous	None
PETN	100% Pentaerythritol tetranitrate	Detonating cord, blasting caps, demolition charge	8,300	1.66	Slight	Excellent
RDX[2]	100% Cyclonite (RDX)	Blasting caps, comp explosives	8,350	1.60	Dangerous	Excellent
TNT	100% Trinitrotoluene	Demolition charge, comp explosives	6,900	1.00	Dangerous	Excellent
Tetryl[2]	100% Tetryl	Booster charge, comp explosives	7,100	1.25	Dangerous	Excellent
Nitroglycerin	100% Nitroglycerin	Commercial dynamites	7,700	1.50	Dangerous	Good
Black powder	74.0% Potassium nitrate 10.4% Sulphur 15.6% Charcoal	Time blasting fuse	400	0.55	Dangerous	Poor
Amatol 80/20	80% NH_4NO_3 20% TNT	Bursting charge	4,900	1.17	Dangerous	Very poor

[1]Compared with TNT = 1.00.
[2]Also used in mines.

Table 2 - (Cont)

Name	Composition	Principal Uses	Velocity of Detonation, meters/sec.	Relative Effectiveness as a Breaching Charge[1]	Intensity of Poisonous Fumes	Water Resistance
Composition A3	91% RDX 9% Wax	Booster charge, bursting charge	8,100	---	Dangerous	Good
Composition B[2]	60% RDX 40% TNT 1% Wax	Bursting charge	7,800	1.35	Dangerous	Excellent
Composition C3	77% RDX 3% Tetryl 4% TNT 10% DNT 5% MNT 1% NC	Demolition charge	7,625	1.34	Dangerous	Good
Composition C4[2]	91% RDX 9% Plasticizer, nonexplosive	Demolition charge	8,040	1.34	Slight	Excellent
Tetrytol 75/25[2]	75% Tetryl 25% TNT	Demolition charge	7,000	1.20	Dangerous	Excellent
Pentolite 50/50	50% PETN 50% TNT	Booster charge, bursting charge	7,450	---	Dangerous	Excellent

[1]Compared with TNT = 1.00.
[2]Also used in mines.